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there are two questions I want to address in this paper.

- 1) what is the evidential status of ~~hypothesized~~ entities such as quarks and theories such as QCD? In particular is ~~there a~~ special problematic associated with just these entities and this theory?

But that leads to the second question of a more general nature

- 2) What is the evidential status of any theoretical entities and their properties and relations as encoded in some area of theoretical discourse, in ~~theoretical~~ physics?

The second question touches on a central concern of general philosophy of science.

But let me start with the first question.

For

quarks just came into the physics vocabulary via the fundamental representation of the $SU(3)$ symmetry introduced into particle physics in the early 1960s by Murray Gell-Mann and Yuval Ne'eman.

The actual ~~particles~~ ^{associated} were represented with terms of higher-dimensional representations of the $SU(3)$ symmetry such as the octet its original eight-fold way if the quarks were at first a somewhat shadowy substratum for backing up the particles actually observed in

* 9 say 'pharynx' focus

one could say that from 1960-1970 (or 1970-1980) an order of concepts and took the seriously and discard the quarks - throwing away the ladder after making the ascent so to speak.

But then in the late 1960s came the deep inelastic electron scattering experiments at SLAC, the verification of Bjorken scaling, and the immediate interpretation in terms of part-like constituents, the parton model of the nucleus. It was then a

small step to identify the partons, which in a sense are called directly 'seen' with the highly energetic quarks.

But with the quarks came the theory of quark interactions, the colour degrees of freedom, the 'gluon fields' and the whole 'apparatus' of non-Abelian gauge theory in the now familiar Standard Model, augmenting the established theory of 'weakened' and Salam with the quantum chromodynamics of strong interactions.

And there were immediate successes in terms of empirical predictions, ~~not~~ quantitatively verified departures from crude Bjorken scaling, the production of jets and so on.

So did physicists believe in the theory? (I will come to philosophers later). Well not exactly, it was not that the theory was empirically refuted for from it, not but there were theoretical

numbers [

A
Smother

hums, they are all the same
purpose, that understanding, and
redefining quantum mechanics —
the problem, however, are greatly
familiar with the subject in the
book, and most physicists in the
book, under the subject in the
book, I would submit.

theory of strong interactions.
Firstly there was the general unsatisfying
business of infinite renormalizations, required of course
even in so-called renormalizable theories.

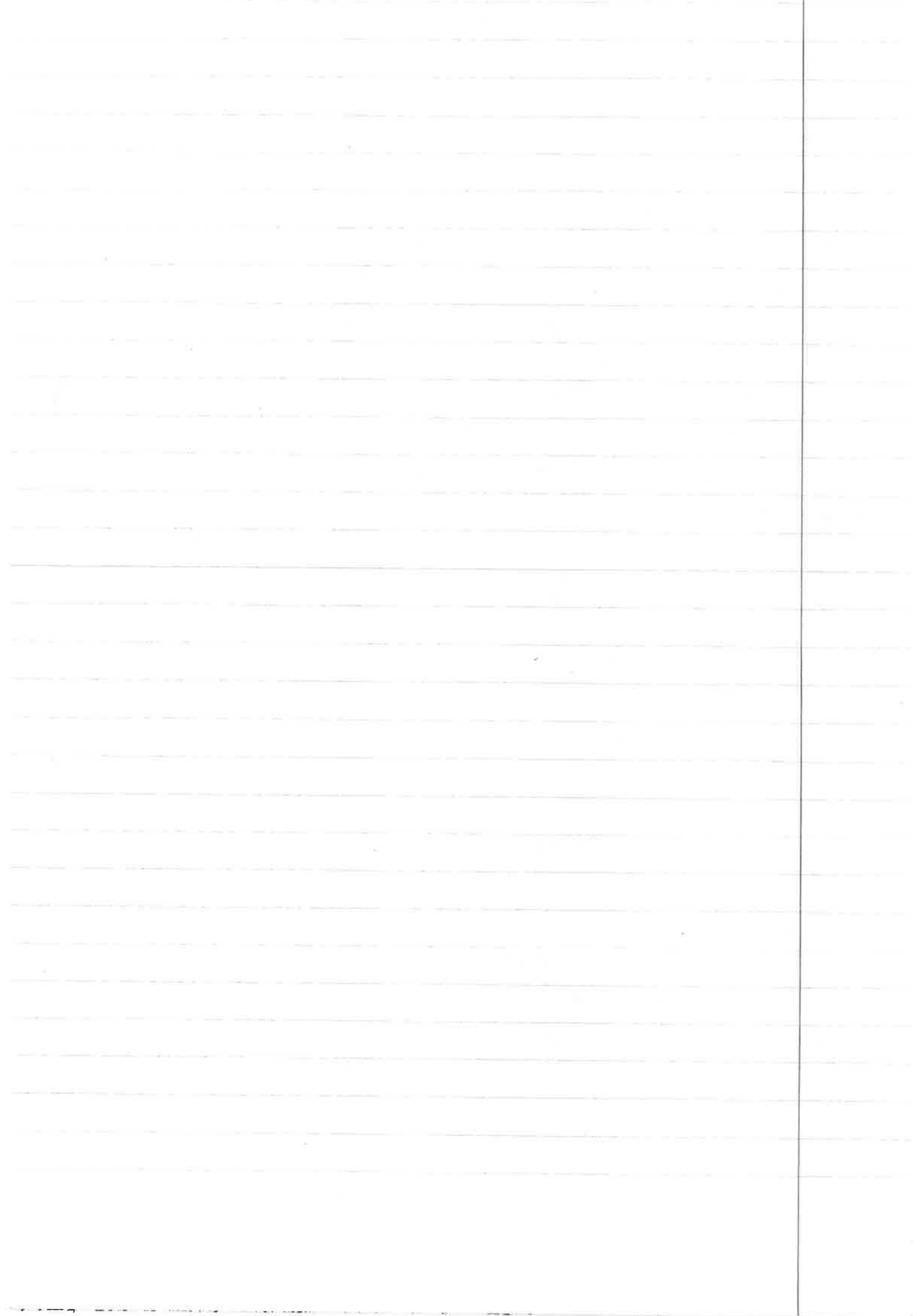
Next physicists regarded renormalized
theories as some sort of "effective
theory", hiding the detail of the 'true'
theory behind renormalized parameters,
whose values were to be taken from
experiment.

Next, there was a sense of
ad hocery in the number of adjustable
parameters in the standard model,
and the curious role of the Higgs
particle in the electro-weak sector.

Then finally physicists were drawn by
the holy grail of grand unification,
trying to leptons and quarks in
a single scheme. Grand unified
theories generally predicted the
instability of the proton via the
interconversion of quarks into leptons.

This has not so far been observed,
but most physicists expect that it is
an allowed process, although on a
very long time scale. To that extent
they do not believe in the GUT as
the final theory.

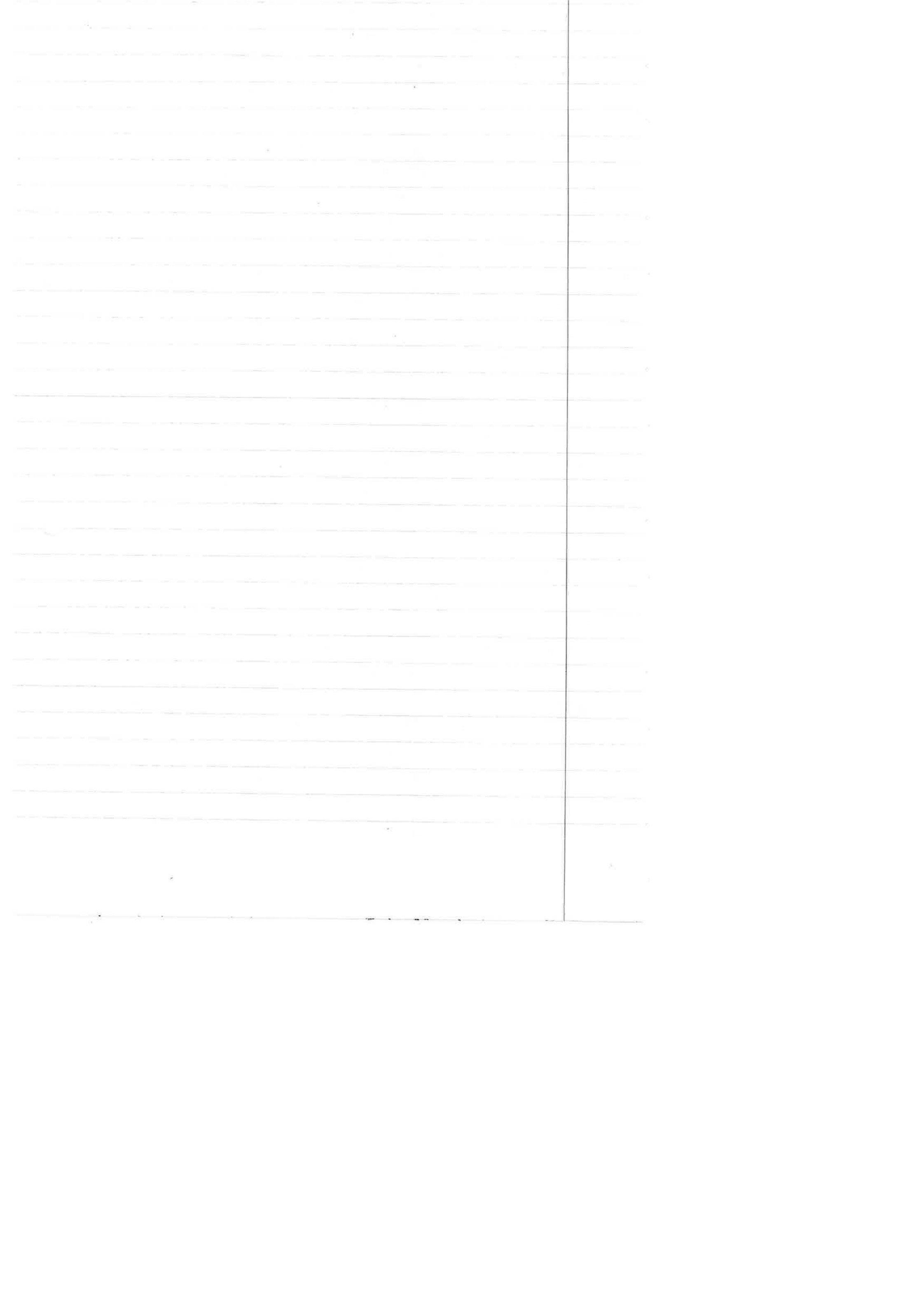
Finally there is of course the whole
question of incorporating gravitation
in a theory of everything and the
recent surge of enthusiasm for
superstring theories.



"Do physicists believe in classical mechanics?" The answer is yes for certain limited purposes of theoretical modelling of phenomena but not in the sense that it is a serious candidate for being the thing dead right - the final answer in strong interaction physics.

[But what about the quarks themselves? This is often thought to be a special problem here associated with the phenomenon of quark confinement. In the past the real has been probed and the manifest electrons, atoms, nuclear and so on could be dealt with simply in their free state and then elegantly explained by an elaborate Aufbau principle putting the single elements together. This is the classical method of analysis of understanding complex whole in terms of their simple constituents. But as a sense the quarks are a sort of counterexample, since they cannot be separated from their partners.

[But this stress on making real entities manifest is a somewhat misleading of what we mean by manifest. The deep inelastic scattering experiments manifest the quarks just as surely, as holding them, 'one at a time',



to speak. Direct observation is
actually pretty 'indirect', so far
as particle physics is concerned.
We see particles by actuals seeing
what they can do. Producing cloud
chamber tracks in bubble chambers, firing
off spark chambers and so on.

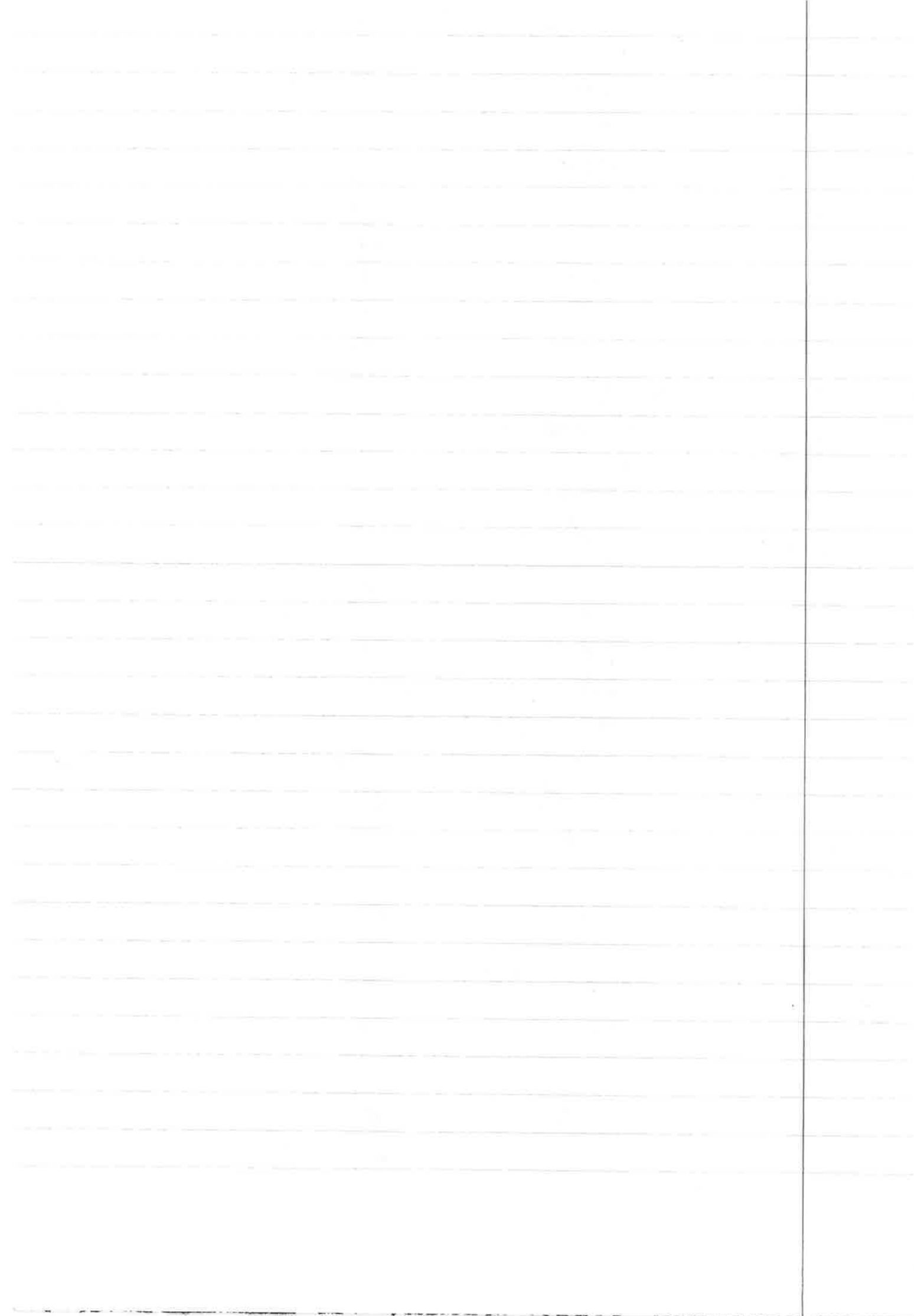
Let me now turn to what a
philosopher might say on reading
the preceding paragraphs, what are
supposed to represent the 'means'
of physicists. I will therefore turn
to my second question, what has
a much broader focus, does not
quarrel over DED.

Is what some should not believe
in secret at all?

There is a broad spectrum of
what I may call isms and schisms
in concerning such a question, which
fill the pages of philosophical paragraphs
and journals.

At one end of the spectrum there are
the relativists, the anti-relativists, the
irrationalists. At the other end are
the realists, the objectivists, the
champions of 'scientific rationality'.
And there is pretty well every shade
in between.

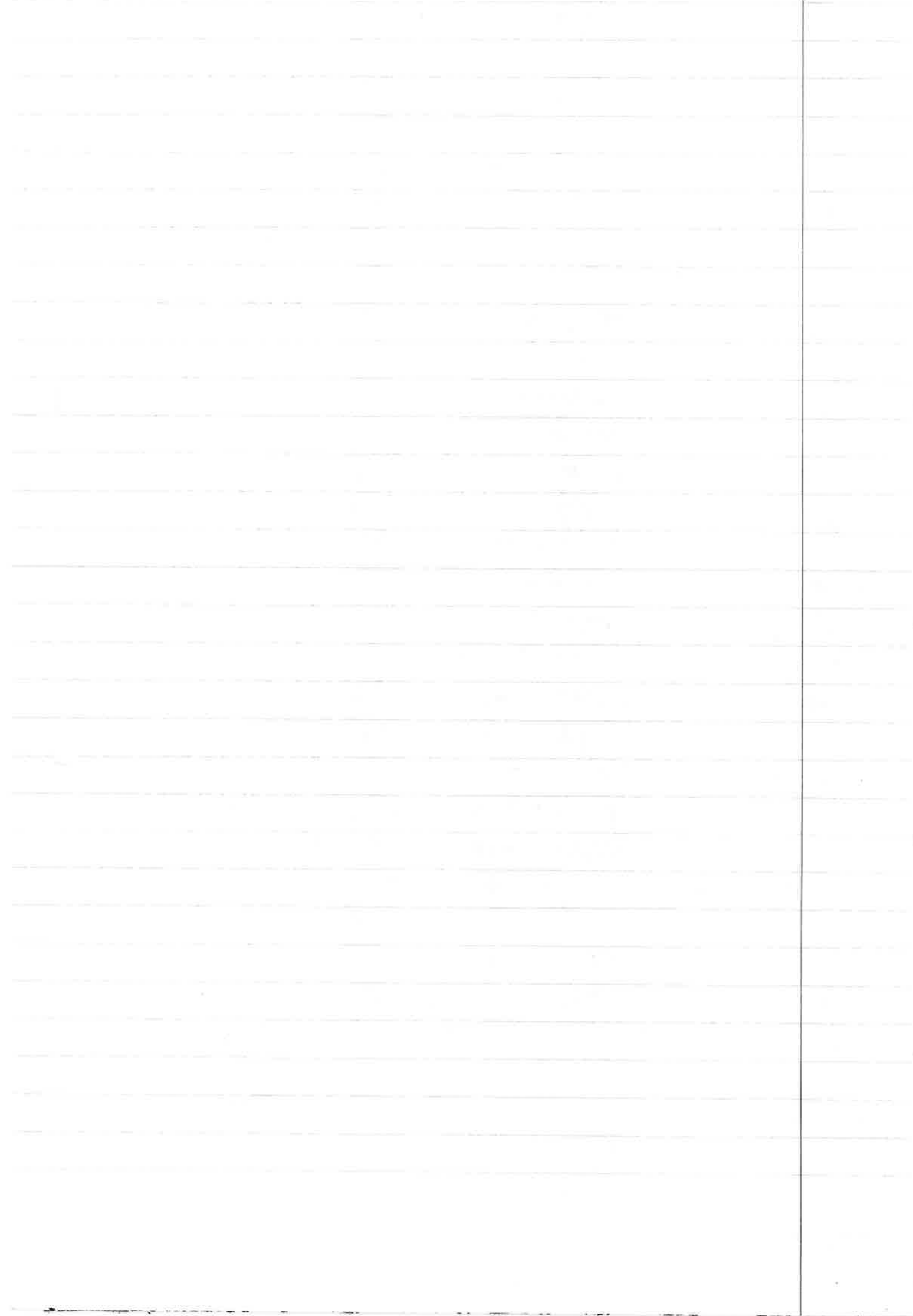
Let me first sketch the extremes, and
then look at the compromises.
But as we shall see, the compromise
positions are greatly ^{hard to} unstable, and



one looks at the matter dispassionately.
So what are the arguments of the
relativist, put in the proverbial nutshell?
First the relativist denies that there
is an objective fact of the matter about
any area of discourse, whether it be
natural science, ethical questions, or
even logic and mathematics. There
is no ~~an~~ Archimedean point, no
God's-eye perspective, from which
which truth in its sense of
correspondence with what is actually
the case, makes any sense, any
claim to 'grasp reality' as it is
in itself. The Kantian thing-in-itself,
is just 'a metaphysical conceit'.

How, say the relativists, could
we achieve knowledge of this
sort either by reason, which they
dismiss as ridiculous, or on the
basis of empirical observation, which,
they say is so conditioned by ethical
presuppositions that it can provide no
sure foundation for knowledge so
the old-fashioned sense of knowing the
objective truth about things which they
are, how they behave and so on.

Everything is relativized to purely
subjective opinions and best interpreted
agreement conditioned not by the world
but its subjective investigation for example,
but by socio-economic factors and
ideologies. Truth comes out as coherence, or



Case: ^{in example} Relativists can well say religion
is true in their sense, but not
because there actually is a God, or
a moral law; and it is the same with
science — 'quarks exist' is true
just in case someone believes that
quarks exist, or maybe because
some small group, such as high-energy
physicists agree that quarks exist, but
never because surplus quarks 'quarks'
do in fact 'exist'. There are two
conclusions that we can reach with
this line of thought. Firstly ^{Firstly} one
knows nothing, one is just a
sceptic in the 'jargon' of relativist.
Modelled on gnosticism, or, surprisingly
enough, one knows anything and
everything that one has an opinion or
a belief about, because that is
what a relativist means by
knowing something. Of course
relativism has some apparently
~~disadvantages~~ features — I know that ^{these}
fairies live at the bottom of my
garden, if that is what I or
perhaps my local community believe,
even if nobody else does. For the
relativist, and there is no robust
notion of truth, there is also no
notion of error, of being wrong.
To be wrong in their Richardian
sense is just to disagree with
someone else. But even that is a

curious
counter-intuitive
one

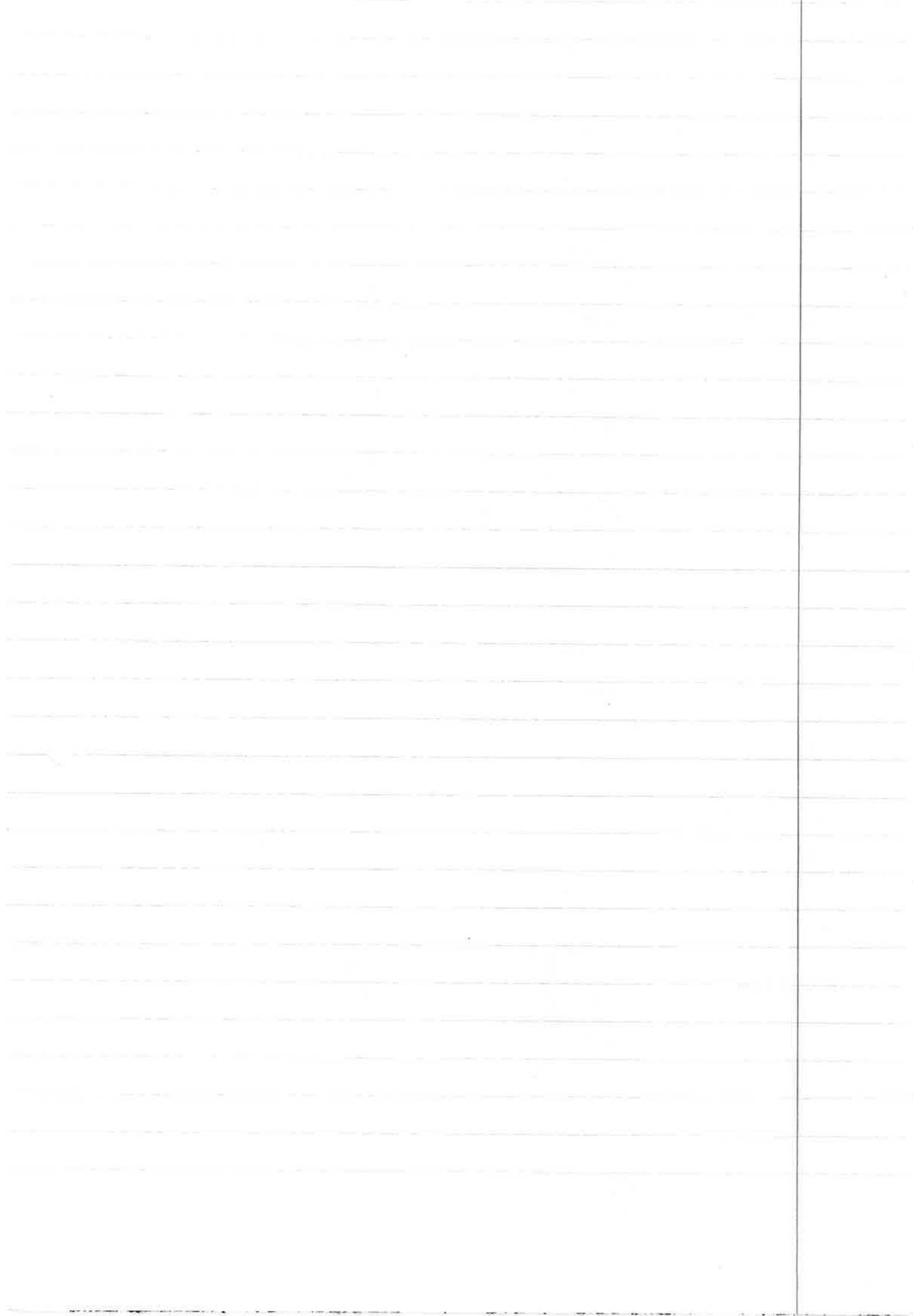
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Sutton

as from your own part of view
if both say they are farmer at
the bottom of his garden and Jill
says she is not. [Why? glared one
that that relativism is true?
well, in that case of true? Relativists
often speak as though the truth of
relativism is the one thing that
they can throw in the old-fashioned sense,
but since they don't admit the
old-fashioned sense, does the truth
of relativism just dissolve into a
matter of mere opinion but then?
Why do they bother with arguments?

The relativists regard their position
as the height of post-modernist
sophistication, but in fact (what does
that mean?) the whole position totters
towards incoherent absurdity.

well Now let us look at the other
extreme, realism. This, roughly, denies
everything that the relativist asserts.

There is an objective world, quite
distinct from our notions and
imaginings, where things either do
exist or do not exist. We may never
come to know decisively which is the
case, but sufficient evidence can
be adduced to bear on the
question to provide degrees of support
or confirmation for the claim that
things exist. Do we know undeniably
the evidential basis itself? No, not for

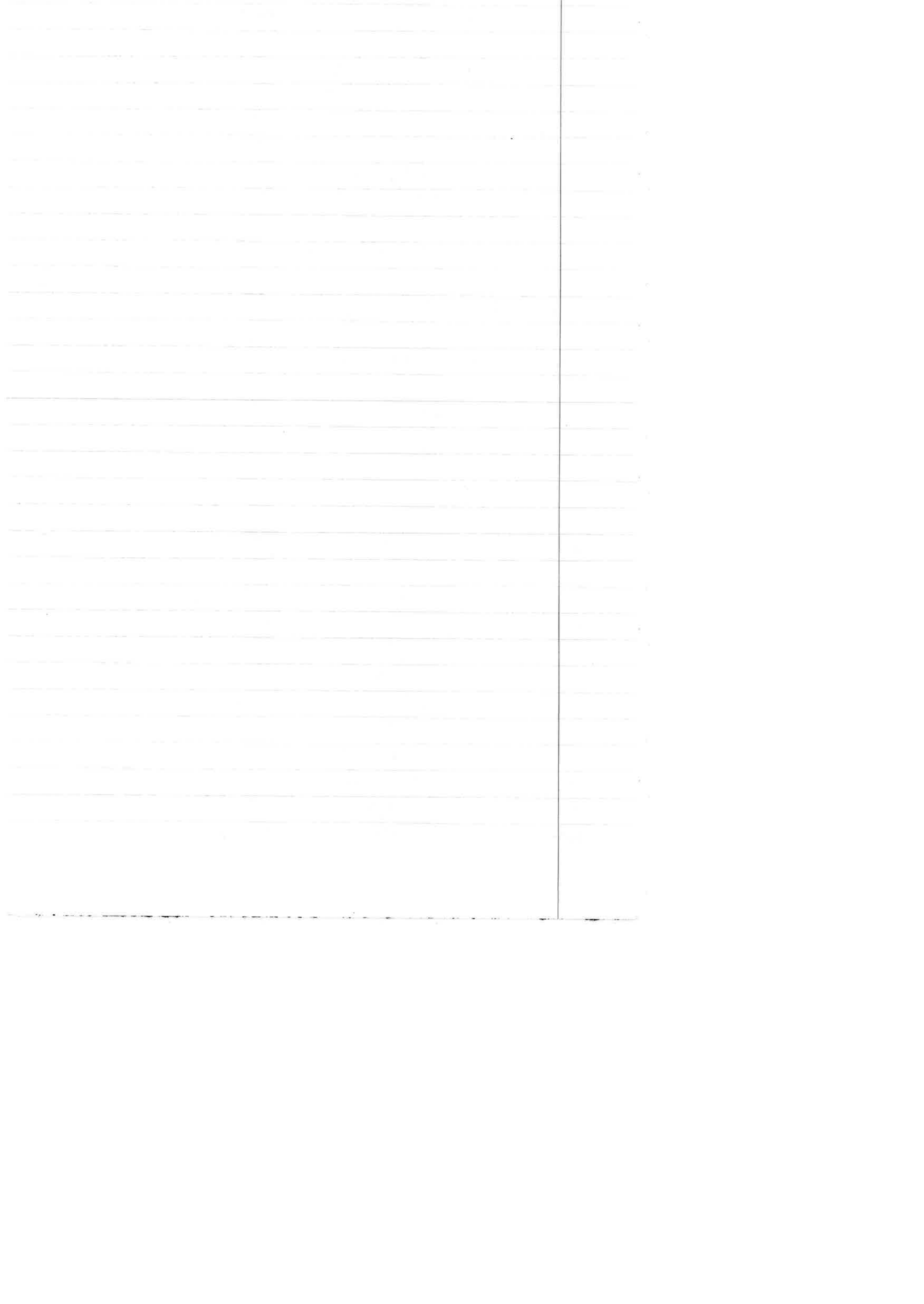


reports, based on the usual procedures of testing and calibration.
new [This all sounds much closer to what the physicist said, but have we really grasped the nitty-gritty of framing law things really are? I believe that Popper had the right approach to such questions. My old mentor Popper had the right approach to this problem.

We conjecture how things are, we are never in a position to know for sure whether we are right, ^{but} all conjectures as not made in a purely formal or speculative way, they are subject to evidential control by the techniques of experiment for science, by observation, by inspecting the world. Popper's ^{main} emphasis was the negative control of refutation and one must not to allow one's more positive sense of support or confirmation. But there is some control, the world picks back, we cannot just make it up anyway that pleases us. We can't construct quarks, we actually over evidence for the conjecture that they do actually exist.

[How what about the compromises?

Well are you so soft on the notion of truth, you have started on a slipping slope, you may try to



man us ^{as} ~~some~~ ^{of} ~~truth~~ ^{disputing}.
eventual consensus of some ~~ideals~~ ^{enquiries}
idealized enquiries, but how can we
tell what makes an idealized enquiry?
I could it be, cynically, just someone
'who ultimately' comes 'to agree with
you yourself?' But the pull to
extreme relativism is really impossible
to resist. So the trick of not tarrying
into a relativist, is not to allow
the first, subtly, allowing more, of
going soft on truth. For quarks, it may
not matter so much, but in everyday
life I believe it really does ~~to~~ make
a difference ^{whether} we believe in mystical
forces ^{or against} in witchcraft and spells
and I know for sure which jetliner I
want to travel in, the realists or
the relativists!

[So let us start again at the
other end, and ask ^{what} ~~the~~ ^{relativists} ~~do~~ ^{do} ~~macroscopic world~~
~~the~~ ^{relativists} ~~do~~ ^{do} ~~macroscopic world~~
everyday life? And if the answer
seems to be ^{yes} ~~no~~ let us
make the reverse slide, if I
can put it like that, from a
robust realism about tables
and chairs, to a definitely more
sceptical realism, but realism all
the same, about quarks and GCD.
I believe the physicists just feeling
for what this is probably right (let
us rather conjecture for you) and I
totally reject the wishy-washy but ultimately

Sweden

a my personal experience in my
mother's work.

is imputed to my socio-economic environment,
I will simply respond: 'pussy cock'.

